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(54) **CONTINUOUS GENERATION AND APPLICATION OF FOAM TO MOVING POROUS SUBSTRATE**

VERFAHREN UND VORRICHTUNG ZUM KONTINUIERLICHEN ERZEUGUNG UND AUFTRAGUNG VON SCHAUM AUF SICH BEWEGENDE PORÖSE SUBSTRATEN

PRODUCTION ET APPLICATION EN CONTINU DE MOUSSE SUR UN SUBSTRAT POREUX EN MOUVEMENT

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Description

This invention relates to an apparatus for continuous application of foam, such as water-based air foam, to a moving porous substrate, such as a web of carpet.

Fluorochemicals, such as Scotchgard™ carpet protector, as well as sulfonated phenolic and methacrylic acid polymeric chemicals, such as Scotchgard™ stain release, can be applied to a web of carpet to impart oil and water repellency and stain resistance. Recent patents disclosing such chemicals are U. S. Patent Nos. 4,937,123 (Chang et al.), 4,822,373 (Olson et al.), 4,540,497 (Chang et al.), 4,839,212 (Blyth et al.), 4,592,940 (Blyth et al.), 4,940,757 (Moss et al.), and 4,925,707 (Vinod). Such chemicals can be applied by immersing the carpet web in an aqueous bath of such chemicals. Upon emergence from the bath, water is expressed from the treated web by rollers or the like. Although this immersion application technique provides excellent penetration, the web remains quite wet after the process and a substantial amount of energy is required to dry the carpet.

Direct spraying of the chemicals onto the web is an alternative to the immersion treatment. Spraying can leave a substantially drier web, reducing the energy costs associated with drying. However, it is difficult to obtain full penetration of the carpet web with traditional spray techniques.

Foam application of treatment chemicals has been suggested in the art for a variety of chemicals and for a variety of fluid permeable or porous substrates or webs. By replacing a portion of the liquid material with air bubbles to provide a foam, the need for drying time is reduced, thereby conserving energy.

A number of patents describe the generation and application of foams. For example, U. S. Patent No. 4,023,526 (Ashmus, et al.) describes a foam applicator head which enables the uniform application of foam to the surface of a substrate, preferably a porous substrate such as textile or fabric, travelling across a nozzle orifice.

U. S. Patent No. 4,440,808 (Mitter) describes a method for the application of a foam treatment medium to a foraminous workpiece such as a textile web. In the described method, the foam is first drawn into the web by suction and subsequently pressed in by squeezing.

U. S. Patent No. 4,562,097 (Walter et al.) describes a process for treating a porous substrate with a textile treating composition in foam form that is applied to the substrate by an applicator nozzle in contact therewith.

U. S. Patent No. 5,009,932 (Klett et al.) describes a method and apparatus for impregnating a porous substrate with foam. The method comprises discharging foam from a discharge head to a porous substrate wherein a foraminous surface positioned opposite to said discharge head enables air to escape from the substrate.

U. S. Patent No. 4,188,355 (Graham et al.) describes a process for production of non-woven mineral fiber mat by applying a binder foam in aqueous media to one surface of a fiber mat, forcing the foam into the mat, and selectively removing a major portion of the aqueous medium from the mat. In one embodiment, a suction device is utilized on the face of the mat opposite to that onto which the foam is spread, to urge the foam into the mat.

U. S. Patent No. 4,288,475 (Meeker) describes a method and apparatus for impregnating a fibrous web comprising a vacuum chamber positioned adjacent to the surface of the web which acts to draw foamed binder material into the web.

U. S. Patent Nos. 4,497,273 (Mitter) and 4,440,808 (Mitter) describe methods for applying foam to a textile workpiece comprising depositing the foam in a confined space atop the workpiece, and applying suction to the workpiece from below.

U. S. Patent No. 4,366,081 (Hull) describes a device for generating foam which comprises a pair of turbulators. Fluid is directed into the first turbulator through a turbulence-generating angle of approximately 90°. The turbulators may be substantially filled with turbulence-generating material providing a plurality of randomly sized and randomly oriented interstices. This material can include metallic pot and pan scrubbing pad comprising a randomly oriented group of thin, flexible turnings.

U. S. Patent No. 4,394,289 (Brown et al.) describes a foam generating apparatus comprising a foam generating chamber substantially filled with turbulator medium. Turbulator material can be stainless steel shavings, stainless steel wire mesh, and the like.

US-A-4,612,874 (upon which the preamble of claim 1 is based) discloses an apparatus or applying foam from a foam generator means to a moving web comprising:

> applicator head means, coupled to said foam generator means, for receiving pressurized foam from said foam generator means and for dispensing said treatment foam onto said moving web, said applicator head having an application slot adapted to extend across the width of said moving web, said application slot being adapted for contact with said moving web,. said application slot defining a foam application site;
>
> suction device means, coupled to a regulated reservoir of subatmospheric pressure for collapsing said foam and for extracting interstitial air from said moving web, said suction device means having a suction slot adapted to extend across the width of said moving web, said suction slot being adapted for contact with said moving web, said suction slot being positioned directly opposite said application slot, said suction slot defining an air extraction site;

said application slot and said suction slot together defining a treatment zone, said treatment zone extending through said moving web from said air extraction site to said foam application site;
whereby a pressure gradient between said foam application site and said air extractor site, is formed within said web in said treatment zone.

Perry, Chem. Eng. Handbook, 6th ed., pp 18-66 to 18-67 (1984) states that metal gauze is known to be useful for foam generation.

Today, increasing use is being made in the manufacture of carpet of foam application equipment such as that supplied by ICS-Texicon, Gaston County Machine Co., Latex Equipment Sales and Service (LESS), Mitter, and the equipment known as the Kusters FLUIDYER KFA 3M Company. This equipment was developed for the application of dyes to porous webs, and is now used to apply the aforementioned Scotchgard™ chemicals, in foam forn, to carpet web. This foam technique continuously injects water-based air foam, into the moving carpet web. This method was developed primarily for the application of dyes to porous webs. See the descriptions of such equipment and practice in "Theory of Operation - 3M Foam Applicator Machine", pp 1-1 to 1-4, and in Zima Corporation's bulletin "Technical and Product Information", January 16, 1984.

Briefly, in one aspect, the present invention provides a foam application device or system, comprising the combination of an applicator head and a suction device, for continuously applying from a suitable foam generator a pressurized temporary foam, such as a water-based air foam containing treatment chemical, to a moving web of fluid-permeable or porous material, such as a web of carpet, as it travels between complementary surfaces of the applicator head and suction device. The applicator head is disposed on one side of the web and has a pressurized foam injector in the form of an application slot which communicates by a passage to an inlet to which foam is continuously supplied under pressure, the slot extending across the web and from which the foam is injected into the web. On the other side of the web, the suction device is disposed and it has a suction or vacuum chamber communicating with a suction slot which also extends across the web and is used to suck, evacuate, or extract air from the web, the suction slot being disposed opposite the application slot. An air cushion means, such as an air-expandable tube or bellows, or other means is used to urge, force, or position the complementary surfaces of the applicator head and the suction device into contact or abutment with the web, thereby preferably compressing or squeezing the web somewhat as it moves and forming a sealed or isolated foam application or injection site. As a result of the intimate contact between the applicator head and suction device with the web and the applied suction, a pressure gradient or differential is formed within, or across, the foam application site of the carpet web, and it promotes thorough penetration of the applied foam into the interstitial spaces of the web and collapses the foam at the foam application site. The foam treated web as it leaves the foam application site is damp but substantially foam-free and can be dried by suitable means to remove residual moisture.

The device can comprise a static foam generator for continuously generating the above-described foam, the generator comprising a pressure chamber, such as a tube, which has an inlet to which air and foamable liquid are supplied and an outlet from which the finished foam is drawn. There is also provided a means for generating a coarse foam which may include, for example, a premixer or foam initiator zone which contains a packing and is adjacent to the inlet end of the chamber to initiate the foaming process by mixing streams of compressed air and foamable liquid in a turbulent random manner, thereby forming a coarse mass of bubbles with a wide size distribution comprising relatively large bubbles which can be perceived by the unaided eye. Said means for generating the coarse foam may also be provided by piping configurations which facilitate the initial mixing of the streams of compressed air and foamable liquid. The initial or coarse foam is driven or pushed by the pressure into a foam restructuring zone which contains substantially rigid packing, such as a roll of mesh or gauze, to subject the coarse foam to ordered turbulence and convert it into a moving mass of uniform microscopic bubbles with a narrow size distribution. The packing in the restructuring zone has small and regular pores and is self-supporting when under the pressure, and, therefore, does not compact or migrate in the restructuring zone.

In the accompanying drawing, where identical reference numerals indicate identical structure;

FIG 1 is a schematic diagram depicting, in elevation, one embodiment of the foam application device of this invention and associated means to continuously transport a web, such as carpet web, by or through the foam application device;
FIG 2 is a schematic diagram of one embodiment of the static foam generator of this invention which can be used to supply foam to the foam application device of FIG 1;
FIG 3 is an isometric view of a partially rolled-up mesh which can be completely rolled up and placed in the foam generator of FIG 2; and
FIG 4 is an enlarged view in partial section of the foam application device shown in FIG 1.

Carpet finishing is often done in a series of processes. The processing begins with an undyed semi-finished web which is dyed in a continuous or batch processes. Usually the dyeing process leaves the web at about 30%-80%

moisture as a percentage of dry carpet weight (%WPU). In this state the carpet may be treated with stain resists and carpet protector chemicals. After treatment, the web will be dried and backed with a secondary backing fabric and latex binder. After additional drying, the finished web is usually trimmed and wound for shipment to the user. This invention will be illustrated as applied to a web of carpet (before it is provided with the secondary backing), but it should be understood that it can be applied to other relatively flexible, porous or fluid permeable substrates or webs, such as other fibrous webs like fabrics or paper.

Turning to FIG 1, there is shown a foam application station 10 for the treatment of a web 11 of carpet continuously traveling, as indicated by the direction arrows, in a conventional carpet processing line (not shown) comprising carpet web handling and transport equipment such as that shown, for example, in the aforementioned "3M Foam Applicator Machine" reference, the web being thus moved across the foam application site generally designated 12 where foam is continuously applied to the traveling web in accordance with the invention. At the application site 12, the foam application device of this invention is disposed, comprising an applicator head 14 and suction device (or "shoe") 15 placed in trough 39, which is mounted on stand 16. The preferred location for the applicator station 10 is after the application of dye to the web and prior to drying and secondary finishing operations.

The carpet web 11 which enters the foam application station 10 is typically semi-finished and often includes tufted yarn anchored at one end in a substrate fabric. In this condition, the web is flexible and quite porous or fluid permeable. And it will usually be somewhat wet from prior processing steps, though the processing variables for the present invention can be adapted to treat a dry web. Although carpet fiber type is an important processing variable, carpets of different types can be treated according to the present invention. However, it should be noted that porosity or fluid permeability of the substrate is required for successful treatment, and for this reason preferably the foam applicator equipment of this invention precedes the conventional latex and backing operations on the processing line.

The treatment chemicals which are incorporated into a foam may vary widely, but the foam application device or system of this invention is particularly advantageous for the application of both a strain resist (or stainblocker) treatment, such as 3M Brand Stain Release Concentrate FX-668F, and a fluorochemical treatment such as Scotchgard™ Carpet Protector FX-1367F. The treatment chemical is mixed with a foaming agent such as a surfactant and diluted with water. Some treatment chemicals, such as those mentioned above, are sold already mixed with the surfactant. The resulting foamable aqueous treatment liquid is then supplied to a foam generator, which can be any conventional or known foam generator but is preferably that of this invention, such as that shown in FIG 2. The foamable aqueous treatment liquid may be premixed as, for example, in a batch operation, or the individual components may be supplied separately on a continuous basis to the foam generator. The foam generator dilutes the treatment liquid with air to form a water-based air foam.

Referring to FIG. 2, the foam generator 17 comprises a cylinder or tube having an inlet end with a fitting 18 for the supply of foamable liquid and a fitting 19 for the supply of compressed air. Adjacent the inlet end there is a premixer or foam initiator zone 21 in which is disposed suitable packing, such as a plurality of compressible, fibrous, porous balls 22 which provide a means for turbulently mixing the streams of foamable liquid and air in a random manner to continuously generate a mass of coarse foam that moves into a foam restructuring zone. The latter zone can be made up of a plurality of sections 23, four of which are shown in FIG. 2, in which are disposed suitable packing, such as rolls 24 of fibrous open mesh, each roll being separated from the other by an annular ring 26 tightly disposed transversely in the generator. FIG. 3 illustrates in detail a roll 24 of said mesh not quite completely rolled up in order to better show its open, porous nature, the mesh having a corrugated nature which thus provides a plurality of longitudinally extending, spiral grooves or channels 25 within and on the outer surface of the roll.

The foam produced by the foam generator as illustrated by FIG. 2, is a two-phase, water-based air foam that is mostly air by volume and mostly water by weight, having only a few tenths of a percent of treatment chemicals by volume. The foam is very uniform with microscopic bubbles, thereby imparting desired stability to the foam, though it can be classified as a temporary form (0.56 litres (a pint) of it collapsing, for example, in about 20 minutes) rather than a persistent or long-lived foam. And the foam has an appearance, loft, and consistency much like that of shaving cream foam produced from an aerosol can).

The foam is pushed through the outlet of the foam generator, transported to the applicator head, and rapidly applied to the web, the residence time of the foam in the apparatus being minimized. Several physical aspects of the foam generator permit it to accomplish this. For example, it is preferred but not required to include the several flow directors within the foam generator shown in FIG. 2. These directors intercept fluid flowing along the interior wall of the generator tube and force it to flow toward the interior of the tube where it is foamed. The foam generator includes a premixer or initial foam zone, or other means for preparing a coarse foam, which insures that the treatment liquid is distributed across the top of the packing material in the foam restructuring zone.

The preferred packing material in the foam restructuring zone is a stainless steel mesh or gauze formed as a knit web and wound into a tight cylinder or roll, as illustrated in FIG. 3. The pore size of this material is both uniform and small, while the void volume is large. Mechanical stability of the roll prevents the packing from compacting in the tube under the operating pressures compatible with this process. The most preferred packing material is the above described

mesh web but with a secondary macro-structure, such as the afore-described corrugation, which enables a dimensionally stable packing with high void-volume to be formed.

Foam generators can be operated at relatively high differential pressures from inlet to outlet ranging from 172 to 689 kPa (25 to 100 psig). Preferred static pressures as measured in the slot should range between 0.69 to 172 kPa (0.1 to 25 psig). At these pressures, the mass flow rate of foam can vary from 50 to 25,000 grams per minute. At the lower mass flow rates, the foam generator can process between 1 and 4 liters per minute of air, while the foam generator can foam between 500 and 2000 liters per minute of air at the higher foam mass flow rate.

Referring to FIGS. 1 and 4, the foam is continuously supplied via line 31 to inlet 32 at the foam applicator head 14 under a pressure, for example, about 0.69 to 172 kPa (0.1 to 25 psi) above ambient, and passes via passage 33 to the application slot 34 in the web-contacting face 35 of the applicator head. Directly opposite the application head 14 is a suction device 15 having a web contacting face 36 that is preferably convex or curved, as shown in FIG. 4, and which is forced into engagement with the web 11 and applicator head 14 by an adjustable air cushion 38 disposed in trough 39 in which suction chamber housing 41 is disposed above cushion 38. The force generated by the air cushion 38 seals the web 11 between the face 35 of the applicator head 14 and the complementary face 36 of the suction device and, in the case where the web is composed of tufted yarn, compressed or presses down the tufted yarn.

The suction device 15 has a suction chamber 42 which is evacuated via pipes 44, 46 by a suitable vacuum system, not shown, suction chamber communicating with a suction slot 47 that is disposed opposite the application slot 34. The suction or reduction in pressure within the suction device 15 will be, for example, between 0 and 152 cms (0 and 60 inches) of water, with the preferred operating range laying between 12.7 and 101 cms (5 and 40 inches) of water. The suction should be sufficient to remove the air but not so high that liquid is pulled through the substrate. The flow of the foam in applicator head 14 and the flow of evacuated air in suction device 15 is illustrated in FIG. 4 by the arrows.

In the absence of the force applied to the suction device 15, the pressure present in the applicator slot 34 would tend to reduce web contact with the seal surface 35. Absent intimate contact between the web and the seal surfaces, the foam treatment would leak onto the top surface of the carpet web 11 and permit ambient air pressure to be established in the web under the applicator slot 34. It is preferred to apply the force to the movable suction chamber housing 41 which compresses the carpet web enough to prevent the appearance of foam on the top surface of the carpet web. However, it should be appreciated that alternative mounting systems may be adopted to obtain the sealing of the web at the application site 12.

The optimal width of the applicator slot 34 depends on web speed, treatment foam pressure, and other variables. Foam pressure is also an operating variable for the process and the optimal pressure depends primarily on web thickness and porosity. ODerable Dressures are illustrated in the examDles below. Slots 34 and 47 are arranged diametrically across from each other, and it is preferred to have the width of the suction slot 47 exceed the width of the applicator slot 34. These apertures together define a treatment volume within the carpet web.

It is preferred that the suction slot 47 be maintained at a slightly sub-atmospheric pressure, although pressure reductions of from 0 and 152 cms (0 to 60 inches) of water appear operable. The vacuum maintained in the suction chamber 42 removes air from the carpet web at the application site 12 during the carpet treatment process. There are two sources of air which must be accommodated. The carpet web 11 carries some air into the treatment zone while the applicator head 14 also presents some air to the web in the form of the treatment foam. In general, removal of the air within the treatment volume defined in the web of the carpet promotes complete penetration of the treatment chemical into the web.

The suction device useful in the invention is preferably of low weight and low initia such as to allow seams, or other variations in thickness, to move through the foam application device without tearing the web. To further facilitate the moving of the web through the application device, it is preferred that the surface of either or both of the applicator head or suction device is curved such that the surface is closest to the web at the application or suction slot.

It is preferred that the suction device be constructed of chemically resistant material such as stainless steel. In addition, it is preferred that the suction slot be constructed to have structural strength to retain its configuration under in-use stresses.

In a typical application, the suction device face 36 and foam application head face 35 are first forced against the moving web to form a seal between the moving web and the sealing faces 35, Next, the foam is injected into the web. Next, pressure in the suction chamber 42 is reduced until liquid begins to accumulate in the suction chamber. Small accumulations of liquid in the suction chamber indicate that the treatment foam is fully penetrating the web. However, the purpose of the applicator head is to leave the treatment chemical within the web so substantial accumulations of fluid in the suction chamber are undesirable.

Although the present invention is described as using air to produce a foam, other suitable gases can be used. Essentially, the only requirement for a material to be foamable is that the material have appropriate surface tension properties to maintain a bubble or cellular structure for the desired period of time. Materials which are not otherwise foamable can usually be rendered foamable by the addition of a foaming agent such as a surface active agent ("surfactant"). Such agents are well known in the art and include, for example, those described in U. S. Patent Nos. 4,795,590

(Kent et al.), 4,912,948 (Brown, et al.), and 4,023,526.

The apparatus of this invention can be used to treat any porous substrate such as a textile fabric of a non-woven material, paper or leather, with any of the functional chemicals that are normally used in their treatment. Thus, the apparatus can be used to apply a flame retarding composition, a waterproofing or water repellent composition, a latex, a fabric softener, a lubricant, a hand builder, a dye or pigment for coloring the fabric, a sizing agent, a whitening agent or fluorescent brightener, a bleach, a binder for a non-woven fabric, a scouring agent, a radiation curable or polymerizable monomer or polymer or oligomer, or any other material that is normally used or applied to a fabric or similar substrate. As previously indicated, use of the apparatus of this invention permits one to apply the functional or treatment chemical in the form of a froth or foam to the material without employing unnecessarily large quantities of water. In view of the escalating energy costs and short supplies of natural gas and other fuels, this is a distinct advantage since less energy is required to dry the fabric for further and subsequent treatment of the foam treated substrate.

Objects and advantages of this invention are illustrated in the following examples and reference examples which should not be construed to unduly limit the invention. Where the term "RE" is used in this specification it means Reference Example.

RE 1:

To a 20 liter container was added 4000 g Stain Release Concentrate FX-668F available from Minnesota Mining and Manufacturing Company, 540 g Scotchgard™ Carpet Protector FX-1367F available from Minnesota Mining and Manufacturing Company, and 15,460 g water. The resulting mixture was hand stirred with a glass rod to give a foamable liquid.

A foam generating apparatus as illustrated in FIG 2, was used to generate the roam from the above liquid. A clear plastic tube 7.5 cm in diameter and about 100 cm long was used. The premix section was the first section in the tube to contact the liquid to be foamed. This premix section was partially filled with six, 350 g stainless steel sponges, No. 751, available from Flour City Brush Co. of Minneapolis, Minnesota. This premix section was about 15 cm in length and ended at a first flow director. A first annular flow director was cut from a 0.4 cm thick sheet of Teflon™ polytetrafluoroethylene to form a tight transverse fit on the inside surface of the tube and provide a passage for the coarse-foamed air and liquid mixture through an opening of 2.5 cm provided in the center of the flow director. The balance of the foam producing interior of the tube was packed with six, axially aligned, 15 cm wide rolls of woven stainless steel mesh, Goodloe Packing Style 773 (available from Otto H. York Co., Inc.) each of which was rolled into a cylinder with a diameter which just fit within the inside diameter of the tube. The woven mesh, as obtained from the supplier, contains a corrugation pattern which is crimped into the fabric at about a 45 degree angle. Half of the rolls of woven mesh received from the supplier were unwound and rerolled with the opposite side of the woven mesh facing the outside of the roll. This served to reverse the direction of the corrugation pattern. When the rolled mesh was placed into the tube, adjacent rolls of mesh were chosen so that the direction of the corrugations alternated directions. Additional annular flow directors were transversely placed between each roll of woven metal mesh to help prevent the channeling of foam or constituents along the interior wall surface of the tube. These additional flow directors were similar to the first flow director at the end of the premix section, except the center openings were 5 cm in diameter, rather than 2 5 cm. A cap on the inlet end of the tube was fitted with a pipe tee for connecting a 0.5 inch (1.3 cm) diameter inlet tube for compressed air and a 0.5 inch (1.3 cm) inlet tube for the treatment solution. A cap on the opposite end of the tube contained a 0.75 inch (1.9 cm) fitting to connect to a 0.75 inch (1.9 cm) hose of sufficient length to transport the foam to an applicator head. such as that illustrated in FIG. 4, at a pressure of about 138 kPa (20 psi) measured at the outlet end of the generating tube.

The foam generating tube was operated in an essentially vertical position with the inlet end at the top of the tube. The inlet air flow-rate was regulated by a Teledyne Hasting air controller connected to a source of air at 620 kPa (90 psi). The foamable liquid inlet flow-rate was controlled by a moyno 2L2 pump, a Micromotion D12 flow-meter, and a PID controller. A ratio of 50 to 1 in the volume of air, to liquid, at standard temperature and pressure, was used which provided a uniform foam to the applicator head. During operation, the packing in the premix and restructuring zones remained rigid and stationary. Stable foam generation from the outlet tube was achieved within about 2 minutes of commencing the air and foamable liquid flows. The foam generated in the premix zone was relatively coarse, the bubbles ranging from those which were perceptively large, e.g. 2 cm, near the inlet to those which were about 1 mm or smaller near the outlet of the premix zone. The mass of coarse foam upon entering the restructuring zone broke up or was restructured with a mass of small bubbles, 1 mm or less, and as the mass of restructured foam moved toward the outlet, essentially all the bubbles became microscopic adjacent the outlet end of the generator. The above-described restructuring of the foam was observed through the clear plastic wall of the foam generator.

RE 2:

Foam was generated as in RE 1 with a foam generating tube like that used in RE 1 except the tube was operated in an essentially horizontal position. The foam product generated was like that generated in RE 1

RE 3:

Foam was generated as in RE 1 with a foam generating tube like that used in RE 1 except the tube was inverted with the inlet end at the bottom of the generating tube which was operated in an essentially vertical position. The foam product generated was like that generated in RE 1

RE 4:

Foam was generated as in RE 1 with a foam generating tube like that used in RE 1 except the flow directors were not utilized. The foam product generated was like that generated in RE 1

Reference Example c1:

Foam was generated as in RE 1 except the stainless steel sponge in the premix section and the woven mesh in the restructuring zone were replaced with springs of 316 stainless steel, 8.3mm OD (0,320 inches O.D.) and length, wire diameter between 0.838 and 0.889mm (0.033 and 0.035 inch) close coiled (available from Southern Spring).

The springs were dimensionally stable under increasing pressure but produced a non-uniform foam with a wide distribution of bubble sizes. However, the operating range of liquid and air flow-rates and blow-ratios which give satisfactory foams was not as great as that in RE 1

Reference Example c2:

Foam was generated as in RE 1 except the woven mesh in the restructuring zone was replaced by more of the stainless steel sponge used in the premix section. This packing material gave satisfactory foam at low flow rates and low pressures. However, when the pressure in the generating tube was raised to approximately 138 kPa (20 psi) or higher, the packing material began to compact, tending to restrict the flow. This compaction caused further pressure buildup which caused further compaction of the packing material, further inhibiting flow of foam through the foam generating section and out from the outlet end of the tube.

Reference Example c3:

Foam was generated as in RE 1 except the premix section was not included. The air and liquid components passed separately through the woven mesh and produced an unsatisfactory coarse foam, resembling used dishwater soap suds.

RE 5:

Foam was generated as in RE 1 except the function of the premix section was provided by supplying the air and treatment solution mixture by means of a one inch PVC pipe about 1 meter in length in an essentially horizontal orientation. The air and treatment solutions were introduced into the PVC pipe individually by tee fittings aligned so that the opening to the pipe was pointing up from the horizontal axis of the pipe. The outlet end of the horizontal PVC pipe was connected by means of an elbow fitting to a 25 cm length of 1.27 cm (1/2 inch) PVC pipe at right angles to the 1 inch pipe. Said 1.27 cm (1/2 inch) pipe was aligned in a vertical orientation extending up from the 2.54 cm (one inch) diameter pipe to assure the air flow and treatment solution flow would engage in some coarse foam generation. The vertical 1.27 cm (1/2 inch) pipe was then connected by means of a flexible plastic hose (about 1.9 cm (3/4 inch) in diameter) to the top of the foam generation tube, which top was at about the elevation of the 2.54 cm (1 inch) horizontal pipe. A coarsely generated foam-air-liquid mixture was thus fed to the inlet of the generating tube. The coarse foam-air-liquid mixture was able to cover the top of the woven mesh section to enable back pressure to build, thus performing the function of the premix. The foam product generated was like that produced in RE 1

Example 6:

A suction device (vacuum shoe) was made from stainless steel. First, 6 separate parts were prepared; 2 right side

pieces, 2 left side pieces, and 2 center spacers. The side pieces were cut to shape, rolled, and tungsten inert gas welded together to form the right side and left side of the suction device. The two sides were welded, and then pipe outlets were added. The suction device was then straightened at elevated temperatures to within 0.32 cm (1/8") over its length. Foam was generated as in RE 1 and the resulting foam was passed to an applicator head of a Kusters FLUIDYER KFA type 272.59 machine having a manifold with a 10 cm wide foot which was 50 cm long with a slot 2 mm wide extending the length of the applicator head. The foam was delivered to the exit of the slot in the applicator head at a pressure of about (1 psi) 6.89kPa and used to treat samples of style # 1699 mock-dyed nylon 6 carpet (available from Shaw Industries). The applicator head was a manifold with a contact surface and a slot in the manifold 2 mm wide through which the foam was delivered. The length of the applicator and slot were 50 cm. The width of the carpet samples treated with this applicator was 50 cm. The carpet was run beneath the applicator and forced toward the applicator by a vacuum shoe beneath the carpet. This pressing of the carpet toward the applicator prevented the foam from escaping the application area.

Beneath the carpet, at the point of contact by the applicator head, was provided a vacuum shoe coextensive with the applicator head also containing a slot. The width of the slot in the vacuum shoe was 0.3 cm. The chamber beneath the slot was attached to a Dayton Industrial model 4Z664A wet and dry vacuum to provide a source of vacuum of about 50.8 cm (20") of water.

A 50 cm wide section of carpet web was passed through the constriction formed by the applicator head and the vacuum backup shoe at a rate of 30 FPM. The treatment solution described as RE 2 was converted to foam as described in RE 2 and delivered to the carpet at the rate of 884 g/min total solution. The delivery rate was calculated to apply the treatment solution on to the carpet to give a wet pickup of 15 weight %. The treated carpet sample was dried at about 120 degree c for 10 min. The penetration of the treatment solution was tested.

Comparative Example C4:

Carpet was treated as in Example 6 except without the vacuum shoe and a porous cover was placed over the air cushion.

Example 7:

Foam was generated, and carpet was treated as in Example 6 except the substrate used was beige Mission Bay carpet of nylon 6 available from Hollytex Carpet Mills.

Example 8:

Foam was generated, and carpet was treated as in Example 6 except the substrate used was Style # 2814 mock-dyed carpet of nylon 6,6 available from Shaw Industries.

Comparative Example C5:

Carpet was treated as in Comparative Example C4 except the substrate used was the same as used in Example 7.

Comparative Example C6:

Carpet was treated as in Comparative Example C4 except the substrate used was the same as used in Example 8.

The stain resist penetration of the foam into the carpet was evaluated by the use of the "Kool-Aid Test" as described in U. S. Patent No. 4,937,123. In addition to the staining of the carpet samples as described, the effectiveness of the treatment was evaluated by examining the entire length of the tufts which make up the carpet. The penetration rating (in %) was determined by measuring the length of the carpet tufts which attained a stain rating of at least 3 and dividing that length by the length of the entire tuft. The results are shown in TABLE 1.

TABLE 1

STAIN RESIST PENETRATION			
EXAMPLE	PENETRATION	COMPARATIVE EXAMPLES	PENETRATION
6	100%	C4	82%
7	100%	C5	85%
8	100%	C6	98%

The results in Table I show the increased penetration realized by the use of vacuum director opposite the foam injection zone. Comparative Examples C4-C6 illustrate the standard practice utilized today.

Comparative Example C7

An alternate vacuum location, different from that of this invention was evaluated by placing a vacuum slot immediately prior to the application point of a Gaston County Dual head single feed carpet laboratory FFT system. A treatment composition was prepared as in RE 1 except the additives used were 286 g of 3M™ brand Stain Release Concentrate FX-667F and 64 g of Scotchgard™ Brand Carpet Protector FX-1363 and 10 g of Witconate AOS surfactant per liter of water. The resulting treatment composition was used to generate a foam as described in RE 1 except the blow ratio was 40:1. The flow rate of the foam was adjusted to apply the treatment composition to a carpet section at a rate of 7% wet pickup (with the carpet running under the foam applicator head at a speed of 75 ft/min (about 22 m/min). Said foam was applied to a 50 cm wide section of "Windrift" nylon carpet (available from Hollytex) utilizing a Gaston County Dual head single feed carpet laboratory FFT system, except the applicator was modified to include a source of vacuum. Vacuum was provided by means of a flattened tube inserted directly under the carpet close into the nip area between the hard roll and the carpet backing. One end of the tube was connected to a vacuum source (Dayton Industrial Wet-Dry Vacuum) and the other end was sealed with a slot provided in the tube coextensive with the width of the carpet. The flattened sides of the tube were approximately matched in shape to the nip area formed by the hard roll and the foam applicator. This facilitated locating the vacuum slot as far into the nip area as practical. When the vacuum originly was activated, a region of reduced pressure was achieved beneath the full width of the carpet immediately before the carpet entered the nip between the foam applicator head and the hard driven roll.

Comparative Example C8

Foam was generated, and carpet treated as in Comparative Example C7 except no vacuum was applied.

Comparative Example C9

Foam was generated, and carpet treated as in Comparative Example C7, except the flattened tube applying the vacuum was relocated to the nip area under the carpet and immediately after the foam application slot.

Evaluation of the carpets treated in Comparative Examples C7 and C9 which used vacuum before or after the foam application showed no improvement in stain resist penetration when compared to Comparative Example C8 which did not use vacuum. Comparative Examples C7 - C9 had stain resist penetration results in the range of 50 - 65%, which is considered unacceptable.

Comparative Example c10:

Foam was generated, and carpet was treated as in Example 6, except the foam composition was adjusted to apply a 4% level of FX-668F and 0.434% level of Scotchgard™ FX-1367F on to the carpet at a wet pickup level of 15%. The vacuum slot was in position directly below the foam application head as shown in FIG. 4, but the vacuum was not turned on. An average of two trials gave a 85% stain resist penetration rating.

Comparative Example c11:

Foam was generated, and carpet was treated as in Example 6, except the foam composition was adjusted to apply a 3% level of FX-668F, 0.48% DOSS KaraWet™ (from Rhone Paulenc), and a 0.434% level of Scotchgard™ FX-1367F on to the carpet at a wet pickup level of 15%. The blow ratio of the foam generation step was 60.1. The vacuum slot was in position directly below the foam application head as shown in FIG. 4, but the vacuum was not turned on. An average of two trials gave a 95% stain resist penetration rating.

Claims

1. Apparatus (10) for applying foam from a foam generator means (17) to a moving web (11) comprising:

   applicator head means (14), coupled to said foam generator means (17), for receiving pressurized foam from said foam generator means (17) and for dispensing said treatment foam onto said moving web (11), said applicator head (14) having an application slot (34) adapted to extend across the width of said moving web,

said application slot (34) being adapted for contact with said moving web, said application slot (34) defining a foam application site (12);
suction device means (15), coupled to a regulated reservoir of subatmospheric pressure for collapsing said foam and for extracting interstitial air from said moving web, said suction device means having a suction slot (47) adapted to extend across the width of said moving web, said suction slot (47) being adapted for contact with said moving web, said suction slot (47) being positioned directly opposite said application slot (34), said suction slot defining an air extraction site;
said application slot (34) and said suction slot (47) together defining a treatment zone, said treatment zone extending through said moving web from said air extraction site to said foam application site;
whereby a pressure gradient between said foam application site and said air extractor site, is formed within said web in said treatment zone; characterised in that said apparatus further comprises force means (38) coupled to said applicator head means and to said suction device means, adapted for compressing said web between said application slot (34) and said suction slot (47).

2. The apparatus (10) of claim 1 wherein the foam generator means is a static foam generator (17) comprising an elongated substantially cylindrical pressure chamber having an inlet end and a discharge end, wherein said foam generator is for generating treatment foam from treatment chemicals.

3. The apparatus (10) of claim 2 further comprising premixer means (22) located proximate said inlet end for initiating foaming of said treatment chemical to produce a course foam.

4. The apparatus of claim 3 further comprising foam restructuring means located in said chamber between said premixer means (22) and said discharge end for generating from said coarse foam a substantially uniform foam having microscopic bubbles, wherein said foam restructuring means comprises a plurality of rolls (24) formed from stainless steel mesh, said mesh having a substantially uniform pore size, each roll being tightly wound such that the exterior circumference of each of said rolls conforms to the inside diameter of said cylindrical chamber, said rolls being stacked end-to-end in said cylindrical chamber.

Patentansprüche

1. Apparat (10) zum Schaumauftragen aus einem Schaumerzeuger (17) auf eine sich bewegende Faserbahn (11), umfassend:

Applikatorkopf (14), zusammenarbeitend mit dem Schaumerzeuger (17), zum Aufnehmen von unter Druck stehendem Schaum aus dem Schaumerzeuger (17) und zum Ausbringen des Behandlungsschaums auf die sich bewegende Faserbahn (11), wobei der Applikatorkopf (14) einen Auftragsschlitz (34) aufweist, der über die Breite der sich bewegenden Faserbahn reicht, wobei der Auftragsschlitz (34) auf Kontakt mit der sich bewegenden Faserbahn eingerichtet ist und wobei der Auftragsschlitz (34) eine Schaumauftragsstelle (12) festlegt;
Saugvorrichtung (15), zusammenarbeitend mit einem geregelten unterdruckbehälter, um den Schaum zum Zusammenfallen zu bringen und zum Abziehen von Porenluft aus der sich bewegenden Faserbahn, welche Saugvorrichtung einen Saugschlitz (47) aufweist, der über die Breite der sich bewegenden Faserbahn reicht, wobei der Saugschlitz (47) auf Kontakt mit der sich bewegenden Faserbahn eingerichtet ist, welcher Saugschlitz (47) und wobei der Saugschlitz (47) direkt gegenüber dem Auftragsschlitz (34) angeordnet ist und der Saugschlitz eine Stelle zum Luftabziehen festlegt;
wobei der Auftragsschlitz (34) und der Saugschlitz (47) eine Behandlungszone festlegen, welche Behandlungszone sich von der Stelle zum Luftabziehen durch di.e Faserbahn hindurch zu der Schaumauftragsstelle erstreckt;
wodurch ein Druckgradient zwischen der Schaumauftragsstelle und der Stelle zum Luftabziehen in der Behandlungszone im Inneren der Faserbahn gebildet wird;

dadurch gekennzeichnet, daß der Apparat ferner Mittel zum Druckausüben (38) aufweist, zusammenarbeitend mit dem Applikatorkopf und der Saugvorrichtung und eingerichtet zum Zusammendrücken der Faserbahn zwischen dem Auftragsschlitz (34) und dem Saugschlitz (47).

2. Apparat (10) nach Anspruch 1, bei welchem der Schaumerzeuger ein statischer Schaumerzeuger (17) ist, umfassend eine langgestreckte und im wesentlichen zylindrische Druckkammer mit einem Einlaß-Ende und einem Aus-

stoß-Ende, welcher Schaumerzeuger zum Erzeugen von Behandlungsschaum aus Behandlungs-Chemikalien dient.

3. Apparat (10) nach Anspruch 2, ferner umfassend Vormischer (22), unmittelbar befindlich am Einlaß-Ende, um die Schaumbildung der Behandlungs-Chemikalien auszulösen und einen groben Schaum zu erzeugen.

4. Apparat (10) nach Anspruch 2, ferner umfassend Schaum-Restrukturiervorrichtung, befindlich in der Kammer zwischen dem Vormischer (22) und dem Ausstoß-Ende, um aus dem groben Schaum einen weitgehend gleichförmigen Schaum mit mikroskopisch kleinen Bläschen zu erzeugen, wobei die Schaum-Restrukturiervorrichtung eine Vielzahl von Rollen (24) aufweist, die aus rostfreien Stahlmaschen gebildet sind, wobei die Maschen eine weitgehend gleichförmige Öffnungsweite haben und jede Rolle fest aufgewickelt ist, so daß sich der Außenumfang jeder dieser Rollen an den Innendurchmesser der zylindrischen Kammer anpaßt, wobei die Rollen in der zylindrischen Kammer stoßend angeordnet sind.

Revendications

1. Appareil (10) pour appliquer de la mousse à partir d'un moyen générateur de mousse (17) sur une bande mobile (11) comprenant:

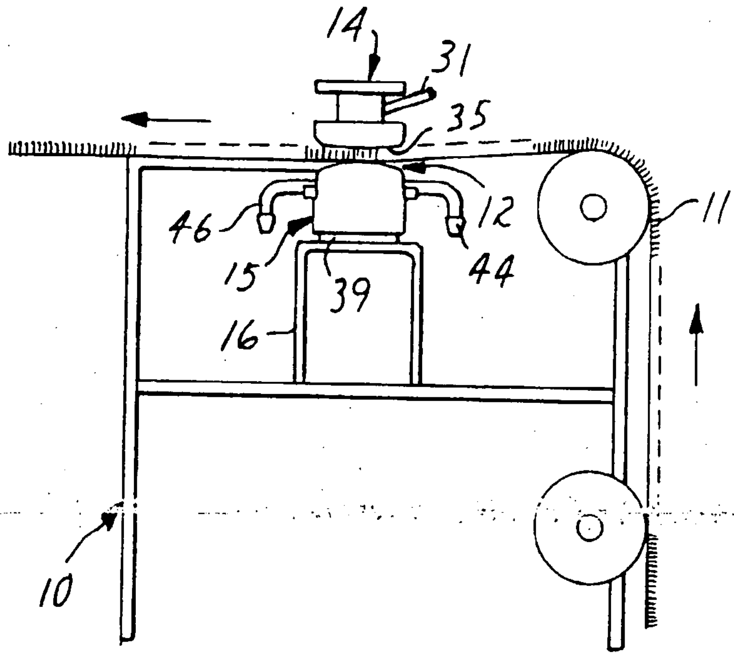
   un moyen de tête d'applicateur (14), couplé au moyen générateur de mousse (17), pour recevoir de la mousse pressurisée du moyen générateur de mousse (17) et pour distribuer la mousse de traitement sur la bande mobile (11), la tête d'applicateur (14) comportant une fente d'application (34) adaptée pour s'étendre à travers la largeur de la bande mobile, la fente d'application (34) étant adaptée pour entrer en contact avec la bande mobile, ladite fente d'application (34) définissant un site d'application de mousse (12);
   un moyen de dispositif d'aspiration (15), couplé à un réservoir ajusté de pression sous-atmosphérique pour affaisser ladite mousse et pour extraire l'air interstitiel de la bande mobile, ledit moyen de dispositif d'aspiration comportant une fente d'aspiration (47) adaptée pour s'étendre à travers la largeur de la bande mobile, la fente d'aspiration (47) étant adaptée pour entrer en contact avec la bande mobile, ladite fente d'aspiration (47) étant positionnée de façon directement opposée à la fente d'application (34), la fente d'aspiration susdite définissant un site d'extraction d'air;
   la fente d'application (34) et la fente d'aspiration (47) définissant ensemble une zone de traitement, ladite zone de traitement s'étendant à travers la bande mobile du site d'extraction d'air au site d'application de mousse;
   de sorte qu'un gradient de pression entre le site d'application de mousse et le site d'extraction d'air, est formé à l'intérieur de ladite bande dans la zone de traitement;

   caractérisé en ce que l'appareil précité comprend de plus un moyen de force (38) couplé au moyen de tête d'applicateur et au moyen de dispositif d'aspiration précités, adapté pour comprimer la bande entre la fente d'application (34) et la fente d'aspiration (47) précitées.

2. Appareil (10) suivant la revendication 1, dans lequel le moyen générateur de mousse est un générateur de mousse statique (17) comprenant une chambre de pression sensiblement cylindrique allongée comportant une extrémité d'entrée et une extrémité de déchargement, ledit générateur de mousse étant destiné à produire une mousse de traitement à partir de produits chimiques de traitement.

3. Appareil (10) suivant la revendication 2, comprenant de plus un moyen prémélangeur (22) agencé à proximité de l'extrémité d'entrée susdite pour amorcer le moussage du produit chimique de traitement et produire une mousse de traitement.

4. Appareil suivant la revendication 3, comprenant de plus un moyen de restructuration de mousse agencé dans la chambre précitée entre le moyen prémélangeur (22) et l'extrémité de déchargement pour produire au départ de la mousse grossière une mousse sensiblement uniforme comportant des bulles microscopiques, dans lequel le moyen de restructuration de mousse susdit comprend une série de rouleaux (24) formés d'une structure maillée en acier inoxydable, ladite structure maillée ayant une taille de pores sensiblement uniforme, chaque rouleau étant enroulé de façon serrée de telle sorte que la circonférence extérieure de chacun de ces rouleaux se conforme au diamètre intérieur de la chambre cylindrique précitée, lesdits rouleaux étant empilés bout à bout dans ladite chambre cylindrique.


14
31
35
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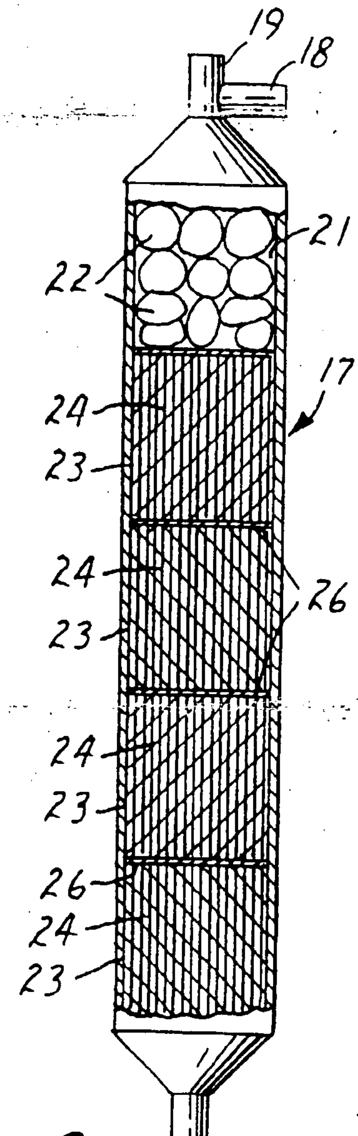
16
10

FIG.1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23

FIG.2

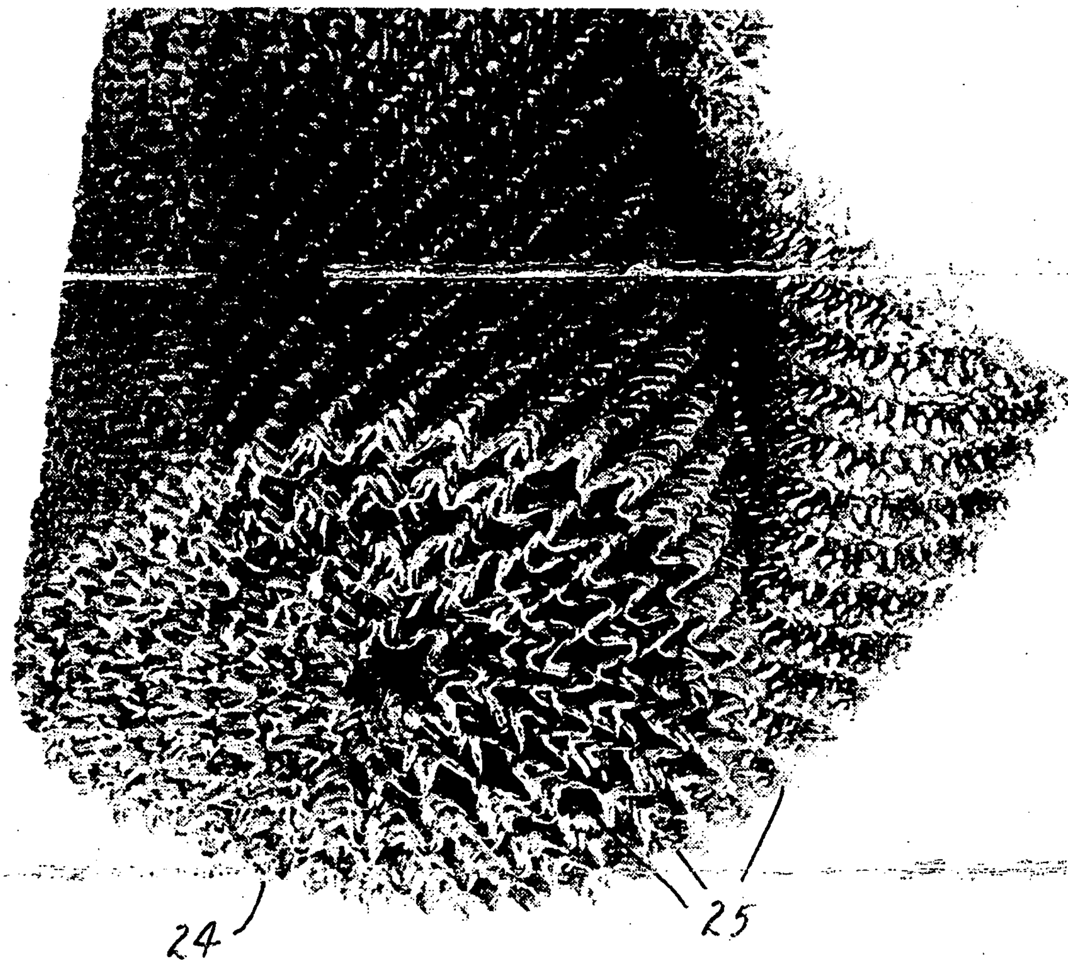

FIG. 3

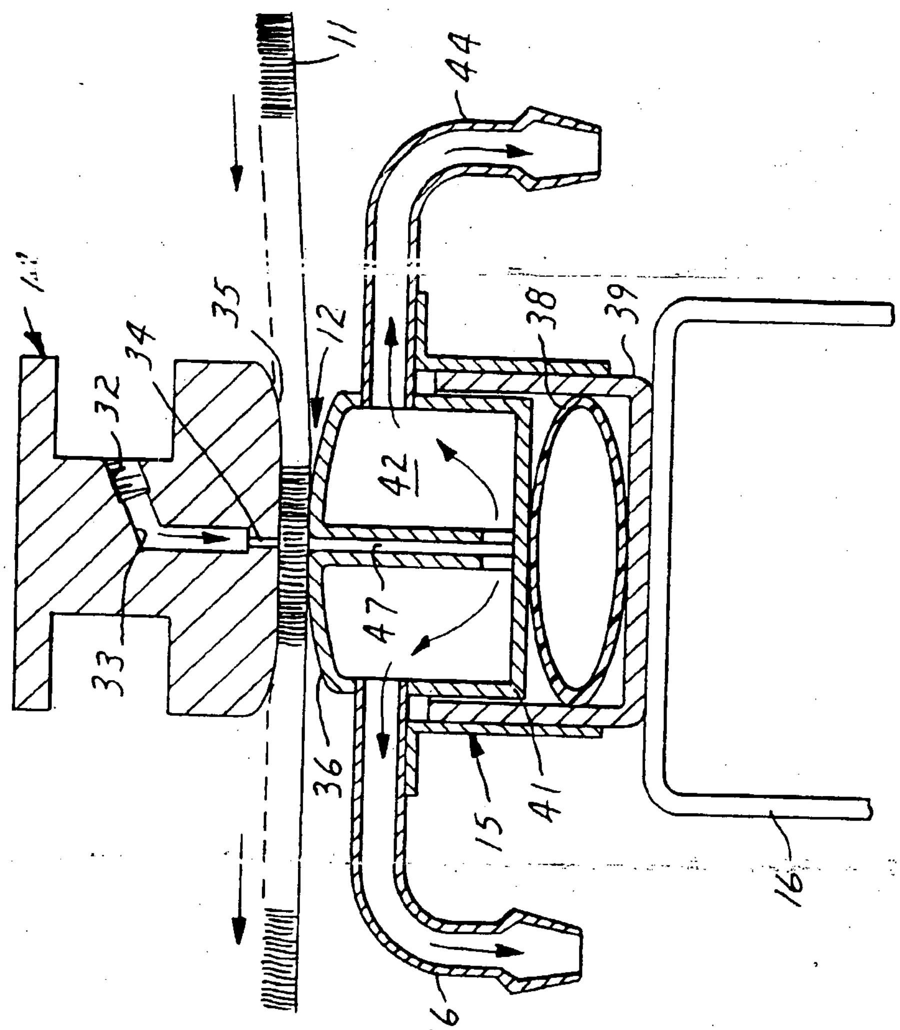

FIG. 4